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## Structure Reports

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**(R)-(–)-Quinuclidin-3-ol**Yoann Rousselin,<sup>a\*</sup> Alexandre Clavel<sup>b</sup> and Isabelle Bonnaventure<sup>b</sup><sup>a</sup>Institut de Chimie Moléculaire de l'Université de Bourgogne - ICMUB, UMR CNRS 6302, Université de Bourgogne, 9, Av. Alain Savary, 21078 Dijon Cedex, France, and <sup>b</sup>CordenPharma – Synkem, 47 rue de Longvic, 21301 Chenove, France

Correspondence e-mail: yoann.rousselin@u-bourgogne.fr

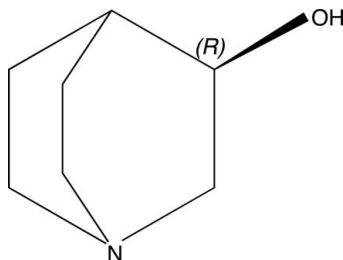
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Key indicators: single-crystal X-ray study;  $T = 100$  K; mean  $\sigma(\text{C}–\text{C}) = 0.003$  Å;  $R$  factor = 0.023;  $wR$  factor = 0.064; data-to-parameter ratio = 14.6.

The structure of the title compound [alternatively called (*R*)-(–)-1-azabicyclo[2.2.2]octan-3-ol],  $\text{C}_7\text{H}_{13}\text{NO}$ , at 100 K has hexagonal ( $P6_1$ ) symmetry. The structure shows a twist along the C–N pseudo-threefold axis. In the crystal, molecules are linked *via*  $\text{O}–\text{H} \cdots \text{N}$  hydrogen bonds, forming infinite chains along the  $c$ -axis direction. The crystal studied was twinned by merohedry (twin law: 010, 100, 001; population: 0.925:0.075).

## Related literature

The title compound is a key building block for the syntheses of muscarinic receptor ligands, including solifenacin (Naito *et al.*, 2005), revatropate (Alabaster, 1997) and talsaclidine (Leusch *et al.*, 2000). For properties of the title compound, see: Bosak *et al.* (2005); Carroll *et al.* (1991); Frackenhohl & Hoffmann (2000); Day & Motherwell (2006); Malone & Armstrong (2006); Siczek & Lis (2008); Sterling *et al.* (1988). For puckering parameters, see: Cremer & Pople (1975); For absolute configuration, see: Flack (1983); The twin law was determined using *TwinRotMat* implemented in *PLATON* (Spek, 2009).



## Experimental

## Crystal data

$\text{C}_7\text{H}_{13}\text{NO}$   
 $M_r = 127.18$   
 Hexagonal,  $P6_1$

$a = 6.2076$  (3) Å  
 $c = 29.8731$  (13) Å  
 $V = 996.91$  (11) Å<sup>3</sup>

$Z = 6$   
 $\text{Cu } K\alpha_1$  radiation  
 $\mu = 0.67$  mm<sup>–1</sup>

$T = 100$  K  
 $0.58 \times 0.44 \times 0.32$  mm

## Data collection

Bruker D8 VENTURE diffractometer  
 Absorption correction: numerical (*SADABS*; Bruker, 2012)  
 $T_{\min} = 0.58$ ,  $T_{\max} = 0.74$

15447 measured reflections  
 1240 independent reflections  
 1240 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.026$

## Refinement

$R[F^2 > 2\sigma(F^2)] = 0.023$   
 $wR(F^2) = 0.064$   
 $S = 1.15$   
 1240 reflections  
 85 parameters  
 1 restraint  
 H-atom parameters constrained

$\Delta\rho_{\max} = 0.23$  e Å<sup>–3</sup>  
 $\Delta\rho_{\min} = -0.12$  e Å<sup>–3</sup>  
 Absolute structure: Parsons & Flack (2004).  
 Absolute structure parameter: 0.01 (4)

Table 1

Hydrogen-bond geometry (Å, °).

$D–H \cdots A$	$D–H$	$H \cdots A$	$D \cdots A$	$D–H \cdots A$
$\text{O1}–\text{H1} \cdots \text{N1}^1$	0.84	2.00	2.8366 (19)	176

Symmetry code: (i)  $y - 1, -x + y, z - \frac{1}{6}$ .

Data collection: *APEX2* (Bruker, 2012); cell refinement: *SAINT* (Bruker, 2012); data reduction: *SAINT*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *OLEX2* (Dolomanov *et al.*, 2009); software used to prepare material for publication: *OLEX2*.

We thank Ms Marie-Jose Penouilh for the NMR and ESI mass spectra.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: BG2517).

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## supplementary materials

*Acta Cryst.* (2013). E69, o1672 [doi:10.1107/S1600536813026998]

**(R)-(-)-Quinuclidin-3-ol**

**Yoann Rousselin, Alexandre Clavel and Isabelle Bonnaventure**

**1. Comment**

(R)-(-)-quinuclidin-3-ol (Figure 1) is a key building block for the syntheses of muscarinic receptor ligands, including solifenacin (M3 receptor antagonist),(Naito *et al.*, 2005) revatropate (M3 receptor antagonist),(Alabaster, 1997) and talsaclidine (M1 receptor agonist),(Leusch *et al.*, 2000).

The asymmetric unit of the crystal (Figure 1) consists of one single (R)-(-)-quinuclidin-3-ol molecule.

The quinuclidinol moiety has pseudo-threefold symmetry about the N1-C3 axis with C6-N1-C1, C1-N1-C5 and C5-N1-N6 angles of 108.86 (15)°, 108.73 (14)° and 108.72 (14)° respectively, and N1-C1-C2-C3, N1-C6-C7-C3 and N1-C5-C4-C3 torsion angles of -0.9 (3)°, 0.4 (2)° and 0.2 (2)° respectively.

The three piperidine rings formed by (N1, C1, C2, C3, C4, C5), (N1, C5, C4, C3, C7, C6) and (N1, C6, C7, C3, C2, C1) adopt a boat conformation with total puckering amplitudes QT of 0.8218 (0) (with  $\Theta = 91.84$  (0)° and  $\varphi = -0.2$  (0)°), QT of 0.8141 (1) (with  $\Theta = 91.55$  (0)° and  $\varphi = 0.19$  (0)°) and QT of 0.8123 (0) (with  $\Theta = 90.95$  (0)° and  $\varphi = -0.17$  (0)°), respectively (Cremer & Pople, (1975)).

There is a hydrogen bond (Table 1) which links molecules into infinite chains along the c axis (Figure 2).

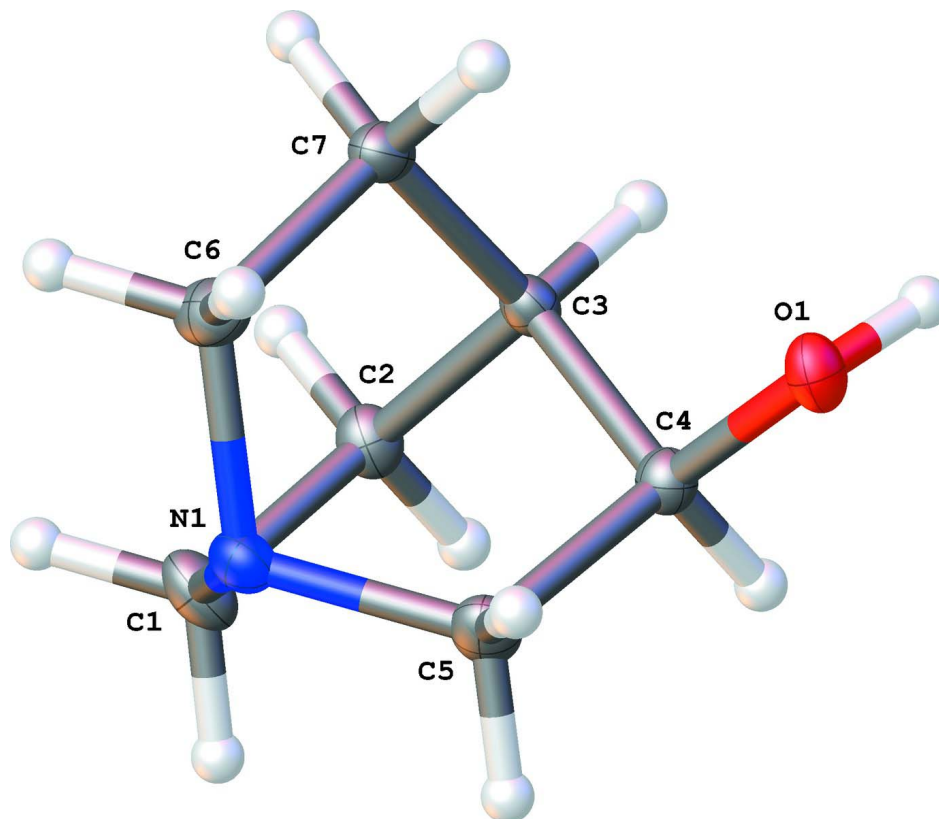
**2. Refinement**

All H atoms, on carbon atom or oxygen atom, were placed at calculated positions using a riding model with C-H = 1 Å (methine), 0.99 Å (methylene) or O-H = 0.84 Å with Uiso(H) = 1.2Ueq(CH), Uiso(H) = 1.2Ueq(CH<sub>2</sub>) or Uiso(H) = 1.5Ueq(OH).

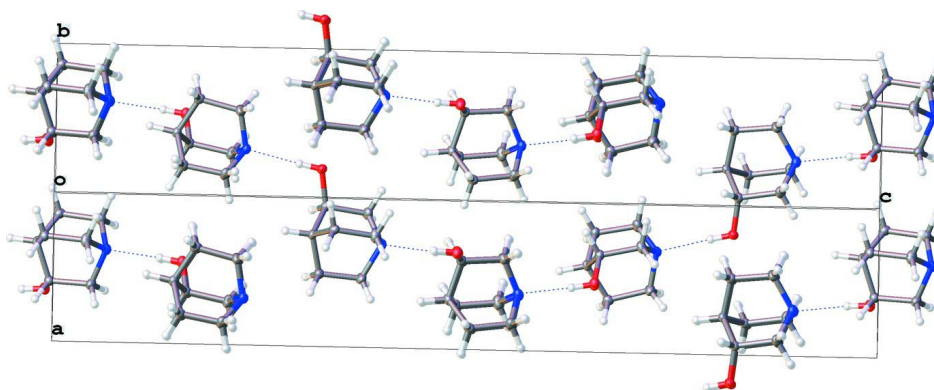
TWIN/BASF refinement type was used to determine absolute configuration from anomalous scattering using the Flack method. (Flack, 1983). The structure display a merohedral twinning and the twin law was found by using TwinRotMat implemented in Platon (Spek, 2009). The use of twin law (0 1 0 1 0 0 0 -1) with a population of 0.925/0.075 reduced the R1(for I > 2σ(I)) and Flack parameter from 4.96%, 0.2 (9) to 2.34%, 0.01 (4).

**Computing details**

Data collection: *APEX2* (Bruker, 2012); cell refinement: *SAINT* (Bruker, 2012); data reduction: *SAINT* (Bruker, 2012); program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *OLEX2* (Dolomanov *et al.*, 2009); software used to prepare material for publication: *OLEX2* (Dolomanov *et al.*, 2009).

**Figure 1**

A view of (*R*)-(-)-quinuclidin-3-ol with atom labelling scheme. The thermal displacement ellipsoids are drawn at 50% probability level.

**Figure 2**

A view of molecular packing showing chains running along the *c* direction. The hydrogen bonds are shown as dashed lines. The thermal displacement ellipsoids are drawn at 50% probability level.

### (*R*)-(-)-Quinuclidin-3-ol

#### *Crystal data*

$C_7H_{13}NO$   
 $M_r = 127.18$

Hexagonal,  $P6_1$   
 $a = 6.2076(3) \text{ \AA}$

$c = 29.8731$  (13) Å  
 $V = 996.91$  (11) Å<sup>3</sup>  
 $Z = 6$   
 $F(000) = 420$   
 $D_x = 1.271$  Mg m<sup>-3</sup>  
Melting point: 492(2) K

Cu  $K\alpha_1$  radiation,  $\lambda = 1.54178$  Å  
 $\mu = 0.67$  mm<sup>-1</sup>  
 $T = 100$  K  
Prism, clear light colourless  
 $0.58 \times 0.44 \times 0.32$  mm

#### Data collection

Bruker D8 VENTURE  
diffractometer  
Radiation source: sealed X-ray tube, high  
brilliance microfocus sealed tube, Cu  
Graphite monochromator  
Detector resolution: 1024 x 1024 pixels mm<sup>-1</sup>  
 $\varphi$  and  $\omega$  scans  
Absorption correction: numerical  
(SADABS; Bruker, 2012)

$T_{\min} = 0.58$ ,  $T_{\max} = 0.74$   
15447 measured reflections  
1240 independent reflections  
1240 reflections with  $I > 2\sigma(I)$   
 $R_{\text{int}} = 0.026$   
 $\theta_{\max} = 69.2^\circ$ ,  $\theta_{\min} = 4.4^\circ$   
 $h = -7 \rightarrow 7$   
 $k = -7 \rightarrow 7$   
 $l = -34 \rightarrow 35$

#### Refinement

Refinement on  $F^2$   
Least-squares matrix: full  
 $R[F^2 > 2\sigma(F^2)] = 0.023$   
 $wR(F^2) = 0.064$   
 $S = 1.15$   
1240 reflections  
85 parameters  
1 restraint  
0 constraints  
Primary atom site location: structure-invariant  
direct methods

Hydrogen site location: inferred from  
neighbouring sites  
H-atom parameters constrained  
 $w = 1/[\sigma^2(F_o^2) + (0.0394P)^2 + 0.1183P]$   
where  $P = (F_o^2 + 2F_c^2)/3$   
 $(\Delta/\sigma)_{\max} < 0.001$   
 $\Delta\rho_{\max} = 0.23$  e Å<sup>-3</sup>  
 $\Delta\rho_{\min} = -0.12$  e Å<sup>-3</sup>  
Extinction correction: SHELXL97 (Sheldrick,  
2008),  $F_c^* = kF_c[1 + 0.001x F_c^2 \lambda^3 / \sin(2\theta)]^{-1/4}$   
Extinction coefficient: 0.0156 (15)  
Absolute structure: Parsons & Flack (2004).  
Absolute structure parameter: 0.01 (4)

#### Special details

**Geometry.** All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

**Refinement.** Refined as a 2-component twin.

#### Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å<sup>2</sup>)

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
O1	-0.1928 (2)	0.4528 (2)	0.48963 (4)	0.0175 (3)
H1	-0.2253	0.4264	0.4622	0.026*
N1	0.3057 (3)	0.6832 (3)	0.56404 (5)	0.0157 (4)
C2	0.5095 (3)	0.8018 (3)	0.48879 (6)	0.0166 (4)
H2A	0.5325	0.9500	0.4722	0.020*
H2B	0.6378	0.7625	0.4786	0.020*
C4	0.0565 (3)	0.6495 (3)	0.49520 (5)	0.0149 (4)
H4	0.0812	0.7999	0.4785	0.018*
C1	0.5354 (4)	0.8550 (4)	0.53973 (6)	0.0208 (4)
H1A	0.6752	0.8380	0.5515	0.025*
H1B	0.5744	1.0283	0.5450	0.025*

C7	0.2139 (3)	0.3542 (3)	0.50634 (5)	0.0159 (4)
H7A	0.3369	0.3067	0.4966	0.019*
H7B	0.0450	0.2111	0.5013	0.019*
C5	0.0986 (4)	0.7091 (4)	0.54597 (5)	0.0188 (4)
H5A	0.1340	0.8814	0.5510	0.023*
H5B	−0.0557	0.5956	0.5624	0.023*
C3	0.2487 (3)	0.5801 (3)	0.47977 (6)	0.0141 (4)
H3	0.2279	0.5406	0.4471	0.017*
C6	0.2509 (4)	0.4253 (4)	0.55649 (6)	0.0204 (4)
H6A	0.0984	0.3095	0.5732	0.024*
H6B	0.3897	0.4068	0.5684	0.024*

*Atomic displacement parameters (Å<sup>2</sup>)*

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
O1	0.0134 (6)	0.0222 (6)	0.0150 (6)	0.0076 (5)	−0.0012 (4)	−0.0004 (5)
N1	0.0176 (7)	0.0155 (8)	0.0128 (7)	0.0074 (6)	−0.0005 (6)	−0.0014 (5)
C2	0.0149 (8)	0.0186 (9)	0.0145 (8)	0.0069 (7)	0.0009 (7)	0.0010 (6)
C4	0.0150 (8)	0.0161 (8)	0.0138 (8)	0.0079 (7)	−0.0002 (6)	0.0006 (7)
C1	0.0176 (9)	0.0215 (9)	0.0164 (9)	0.0045 (8)	−0.0020 (6)	−0.0034 (7)
C7	0.0150 (8)	0.0151 (8)	0.0177 (8)	0.0077 (7)	−0.0012 (6)	−0.0028 (7)
C5	0.0207 (9)	0.0237 (9)	0.0153 (8)	0.0135 (8)	−0.0006 (7)	−0.0042 (7)
C3	0.0135 (8)	0.0158 (8)	0.0124 (8)	0.0068 (7)	−0.0011 (6)	−0.0024 (7)
C6	0.0292 (9)	0.0186 (9)	0.0159 (9)	0.0139 (8)	−0.0003 (8)	0.0013 (7)

*Geometric parameters (Å, °)*

O1—H1	0.8400	C1—H1A	0.9900
O1—C4	1.423 (2)	C1—H1B	0.9900
N1—C1	1.475 (2)	C7—H7A	0.9900
N1—C5	1.475 (2)	C7—H7B	0.9900
N1—C6	1.479 (2)	C7—C3	1.530 (2)
C2—H2A	0.9900	C7—C6	1.546 (2)
C2—H2B	0.9900	C5—H5A	0.9900
C2—C1	1.548 (2)	C5—H5B	0.9900
C2—C3	1.536 (2)	C3—H3	1.0000
C4—H4	1.0000	C6—H6A	0.9900
C4—C5	1.552 (2)	C6—H6B	0.9900
C4—C3	1.528 (2)		
C4—O1—H1	109.5	C3—C7—H7A	110.1
C1—N1—C6	108.86 (15)	C3—C7—H7B	110.1
C5—N1—C1	108.73 (14)	C3—C7—C6	107.96 (13)
C5—N1—C6	108.72 (14)	C6—C7—H7A	110.1
H2A—C2—H2B	108.4	C6—C7—H7B	110.1
C1—C2—H2A	110.0	N1—C5—C4	112.56 (14)
C1—C2—H2B	110.0	N1—C5—H5A	109.1
C3—C2—H2A	110.0	N1—C5—H5B	109.1
C3—C2—H2B	110.0	C4—C5—H5A	109.1
C3—C2—C1	108.29 (15)	C4—C5—H5B	109.1

O1—C4—H4	109.6	H5A—C5—H5B	107.8
O1—C4—C5	107.46 (13)	C2—C3—H3	109.9
O1—C4—C3	112.96 (14)	C4—C3—C2	108.41 (14)
C5—C4—H4	109.6	C4—C3—C7	109.25 (14)
C3—C4—H4	109.6	C4—C3—H3	109.9
C3—C4—C5	107.45 (13)	C7—C3—C2	109.45 (14)
N1—C1—C2	111.72 (14)	C7—C3—H3	109.9
N1—C1—H1A	109.3	N1—C6—C7	112.19 (14)
N1—C1—H1B	109.3	N1—C6—H6A	109.2
C2—C1—H1A	109.3	N1—C6—H6B	109.2
C2—C1—H1B	109.3	C7—C6—H6A	109.2
H1A—C1—H1B	107.9	C7—C6—H6B	109.2
H7A—C7—H7B	108.4	H6A—C6—H6B	107.9
O1—C4—C5—N1	122.04 (17)	C5—C4—C3—C2	−59.75 (17)
O1—C4—C3—C2	−178.09 (13)	C5—C4—C3—C7	59.46 (17)
O1—C4—C3—C7	−58.88 (17)	C3—C2—C1—N1	−0.9 (2)
C1—N1—C5—C4	59.38 (18)	C3—C4—C5—N1	0.20 (19)
C1—N1—C6—C7	−59.78 (19)	C3—C7—C6—N1	0.4 (2)
C1—C2—C3—C4	60.54 (19)	C6—N1—C1—C2	59.72 (19)
C1—C2—C3—C7	−58.55 (18)	C6—N1—C5—C4	−59.01 (19)
C5—N1—C1—C2	−58.6 (2)	C6—C7—C3—C2	58.56 (18)
C5—N1—C6—C7	58.53 (19)	C6—C7—C3—C4	−60.01 (17)

Hydrogen-bond geometry (Å, °)

<i>D</i> —H $\cdots$ <i>A</i>	<i>D</i> —H	H $\cdots$ <i>A</i>	<i>D</i> $\cdots$ <i>A</i>	<i>D</i> —H $\cdots$ <i>A</i>
O1—H1 $\cdots$ N1 <sup>i</sup>	0.84	2.00	2.8366 (19)	176

Symmetry code: (i)  $y-1, -x+y, z-1/6$ .